APPENDIX B

USE OF INSULATION MATERIALS IN PAVEMENTS

B-1. Insulating materials and insulated pavement systems. The only acceptable insulating material for use in roads and airfields is extruded polystyrene boardstock. Results from laboratory and field tests have shown that extruded polystyrene does not absorb a significant volume of moisture and that it retains its thermal and mechanical properties for several years, at least. The material is manufactured in board stock ranging from 1 to 4 inches thick.

a. Experience has shown that surface icing may occur on insulated pavements at times when uninsulated pavements nearby are ice-free and vice versa. Surface icing creates possible hazards to fast-moving aircraft and motor vehicles. Accordingly, in evaluating alternative pavement sections, the designer should select an insulated pavement only in special cases not sensitive to differential surface icing. Special attention should be given to the need for adequate transitions to pavements having greater or lesser protection against subgrade freezing.

b. An insulated pavement system comprises conventional surfacing and base above an insulating material of suitable thickness to restrict or prevent the advance of subfreezing temperatures into a frost-susceptible subgrade. Unless the thickness of insulation and overlying layers is sufficient to prevent subgrade freezing, additional layers of granular materials are placed between the insulation and the subgrade to contain a portion of the frost zone that extends below the insulation. In consideration of only the thermal efficiency of the insulated pavement system, an inch of granular material placed below the insulating layer is much more effective than an inch of the same material placed above the insulation. Hence, under the design procedure outlined below, the thickness of the pavement and base above the insulation is determined as the minimum that will meet structural requirements for adequate cover over the relatively weak insulating material, and the determination of the thickness of insulation and of additional granular material is predicated on the placement of the latter beneath the insulation.

B-2. Determination of thickness of cover above insulation. On a number of insulated pavements in the civilian sector, the thickness of material above the insulation has been established to limit the vertical stress on the insulation caused by dead loads and wheel loads to not more than one-third of the compressive strength of the insulating material. The Boussinesq equation should be used for this determination.

B-3. Design of insulated pavement to prevent subgrade freezing. Once the thickness of pavement and base above the insulation has been determined, it should be ascertained whether a reasonable thickness of insulation will keep subfreezing temperatures from penetrating through the insulation. Calculations for this purpose make use of the design air and surface freezing indexes and the mean annual soil temperature at the site. If the latter is unknown, it may be approximated by adding 7 degrees F. to the mean annual air temperature. If the design surface freezing index cannot be calculated from air temperature measurements at the site, or cannot be estimated using data from nearby sites, it may be estimated by multiplying the design air freezing index, calculated as described in paragraphs 1-2b and 3-2b, by the appropriate n-factor. For paved surfaces kept free from snow and ice, and n-factor of 0.75 should be used. For calculating the required thickness of insulation, the design surface freezing index and the mean annual soil temperature are used with figure B-1 to determine the surface temperature amplitude A. The initial temperature differential v_o is obtained by subtracting 32 degrees F. from the mean annual soil temperature, or it also may be read directly from figure B-1. The ratio v_o/A is then determined. Figure B-2 is then entered with the adopted thickness of pavement and base to obtain the thickness of extruded polystyrene insulation needed to prevent subgrade freezing beneath the insulation. If the required thickness is less than about 2 to 3 inches, it will usually be economical to adopt for design the thickness given by figure B-2, and to place the insulation directly on the subgrade. If more than about 2 to 3 inches of insulation are required to prevent subgrade freezing, it usually will be economical to use a lesser thickness of insulation, underlain by subbase material (S1 or S2 materials in table 2-1). Alternative combinations of thicknesses of extruded polystyrene insulation and granular material (base and subbase) to completely contain the zone of freezing can be determined from figure B-3, which shows the total depth of frost for various freezing indices, thicknesses of extruded polystyrene insulation, and base courses. The thickness of subbase needed to contain the zone of freezing is the total depth of frost penetration less the total thickness of pavement, base and insulation.

B-4. Design of insulated pavement for limited subgrade freezing. It may be economically advantageous to permit some penetration of frost into the subgrade. Accordingly, the total depth of frost penetration given by figure B-3 may be taken as the value a in figure 4-1, and a new combined thickness b of base, insulation, and subbase is determined that permits limited frost penetration into the subgrade. The thickness of subbase needed beneath the insulation is obtained by subtracting the previously established thicknesses of base, determined from structural requirements, and of insulation, determined from figure B-3. Not less than 4 inches of subbase material meeting the requirements of paragraph 5-4 should be placed between the insulation and the subgrade. If less than 4 inches of subbase material is necessary, consideration should be given to decreasing the insulation thickness and repeating the process outlined above.

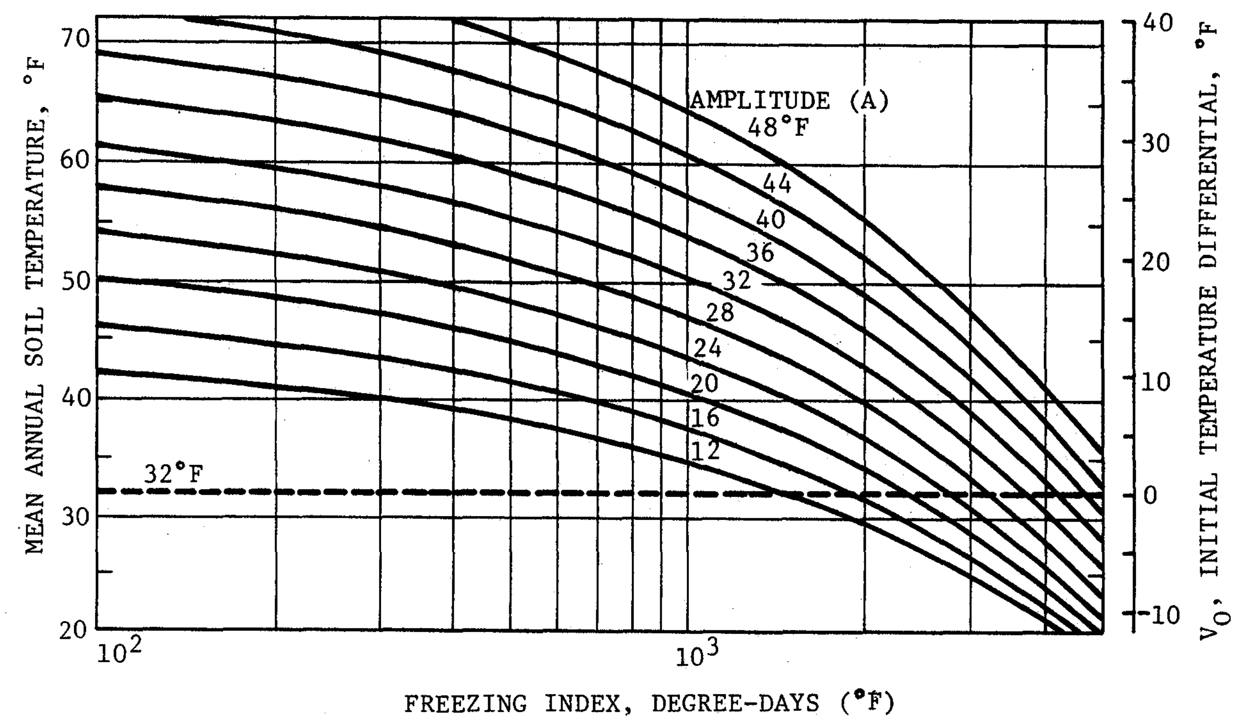

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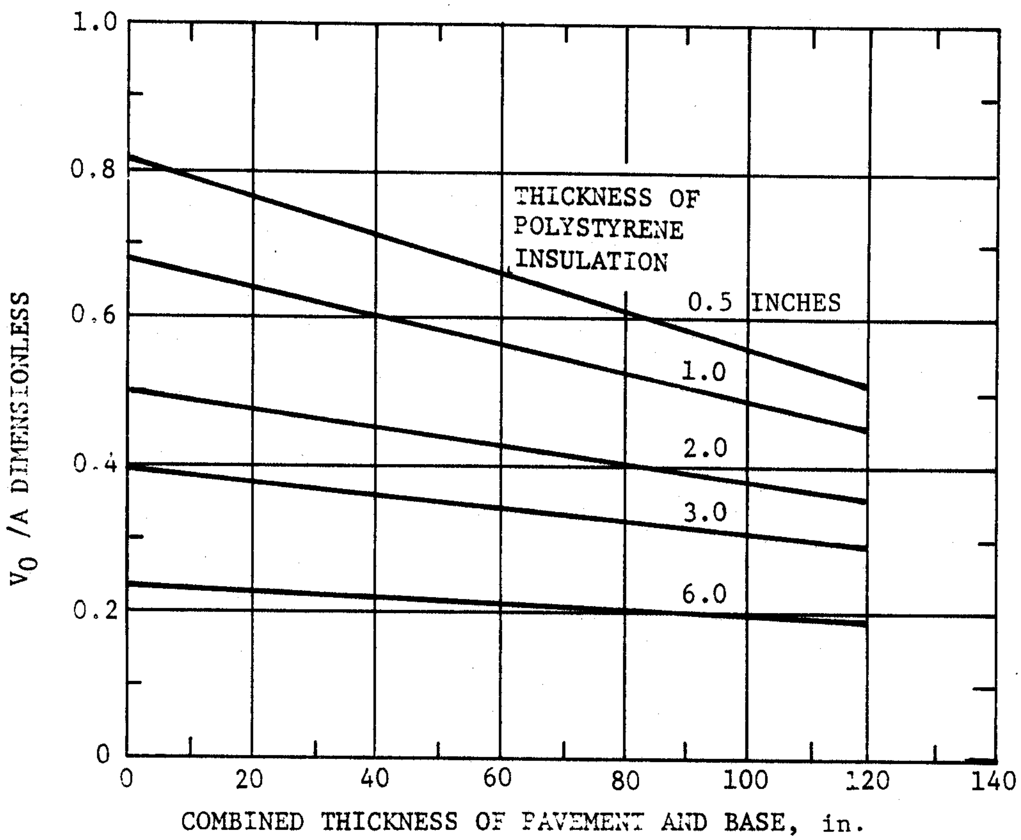
FIGURE B-1. EQUIVALENT SINUSOIDAL SURFACE TEMPERATURE AMPLITUDE A AND INITIAL TEMPERATURE DIFFERENCE, V_0



NOTE: DESIGN CURVES BASED ON THE FOLLOWING MATERIAL PROPERTIES:
PAVEMENT: SAME THERMAL PROPERTIES AS UPPER BASE
BASE: Y_d = 135 pcf, W = 7 PERCENT
EXTRUDED POLYSTYRENE INSULATION

$Y_d = 2.0$ pcf, $K = 0.21 \dfrac{\text{Btu in.}}{\text{ft}^2 \text{ hr } ^\circ\text{F.}}$

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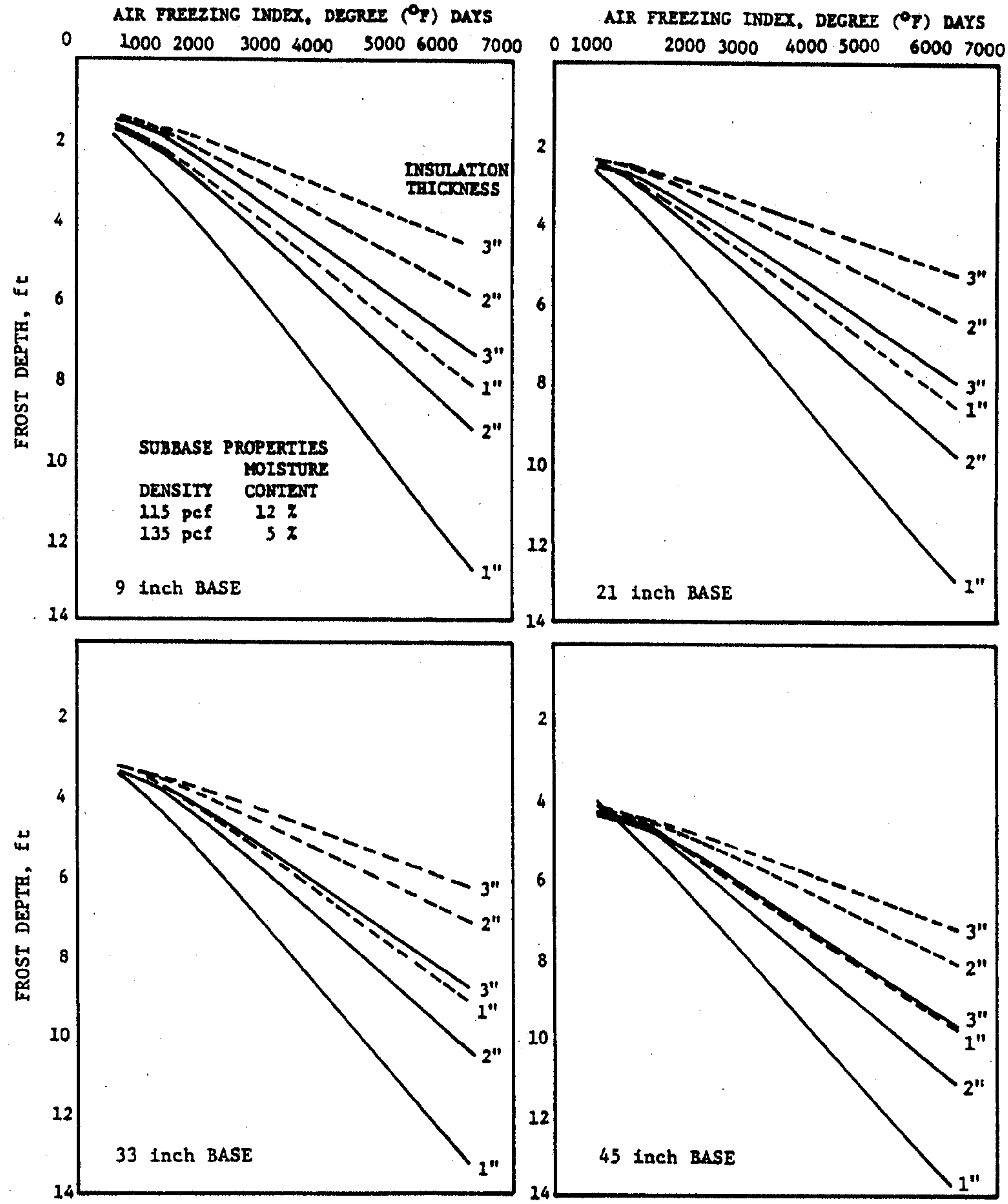
FIGURE B-2. THICKNESS OF POLYSTYRENE INSULATION TO PREVENT SUBGRADE FREEZING



NOTES: PAVEMENT: 3 INCH BITUMINOUS
BASE COURSE: Y_d = 135 pcf, W = 5 percent

INSULATION: EXTENDED POLYSTYRENE

Y_d = 2 pcf; K = 0.21 $\frac{\text{Btu in}}{\text{ft}^2\ \text{hr}\ °\text{F.}}$

UNDERLYING GRANULAR MATERIAL:
——— Y_d = 115 pcf, W = 12 percent
– – – – Y_d = 135 pcf, W = 5 percent

SURFACE TRANSFER COEFFICIENT = 0.75

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FIGURE B-3. EFFECT OF INSULATION THICKNESS AND BASE ON FROST PENETRATION

B-5. Construction practice. While general practice has been to place insulation in two layers with staggered joints, this practice should be avoided at locations where subsurface moisture flow or a high ground water table may be experienced. In the latter cases it is essential to provide means for passage of water through the insulation to avoid possible excess hydrostatic pressure in the soil on which the insulating material is placed. Free drainage may be provided by leaving the joints between insulating boards slightly open, or by drilling holes in the boards, or both.